

THE METHOD

OF TEACHING

LONGFELLOW

AND

STANDARD LAND

OF THE

TEACHER

BY

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After. P. 1812

Whiston

A
New METHOD
For Discovering the
LONGITUDE

BOTH AT
SEA and LAND,
Humbly Proposed to the Consideration of
the PUBLICK.

BY

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and

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don.*

The SECOND EDITION: With great Addi-
tions, Corrections, and Improvements.

L O N D O N:

Printed for Mr. *Whiston* and Mrs. *Ditton*; and
Sold by *J. Roberts* near the *Oxford-Arms-Inn*
in *Warwick-Lane.* 1715.

Bayerische
Staatsbibliothek
München

T O

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PHILIP Lord Bishop of Hereford.*

*The Right Reverend Father in God
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sor of Astronomy.*

*Commissioners appointed by Act of Par-
liament for the Discovery of the
LONGITUDE.*

*This New Method for that Discove-
ry is with all due Submission humbly
Dedicated by*

The Authors.

T H E
INTRODUCTION.

BEfore we come to give an Account of this our New Method for the Discovery of the Longitude, both by Sea and Land, which we here take leave humbly to propose to the Consideration of the Publick, we think it reasonable to premise somewhat by way of Introduction: To give some Account of the Nature of the Problem before us; to speak a little of the Methods hitherto try'd, and the Reasons of their ill Success; and to add a brief Historical Narration from what Occasions and by what Steps this
our

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our Method was first discover'd, and has arriv'd at its present Degree of Maturity.

As to the Problem it self, the Invention of the Longitude ; it is plainly this: To discover in some measure a like sure way of frequently knowing how far we are distant, on the Earth Spherical Surface, in Degrees, from any known Meridian, Eastward or Westward ; as we can easily know, almost at any time, how far we are distant, in Degrees, on the same Surface, from the middle Circle or Equator, Northward or Southward. Now in this Case it must be noted, that as the Diurnal Motion does naturally imply fixed Poles, and a fixed Equator ; which infer a different Meridian Altitude of those Poles, and of that Equator, and by consequence of all the heavenly Bodies, in different Latitudes ; which different Altitude may in clear Weather be easily observ'd by proper Instru-

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Instruments, and thereby that Latitude may be readily discovered; so does not the same Diurnal Motion at all imply any *Phænomena*, whence the Longitude may be discover'd to us: Because the same Parallel still bears, through its whole Circumference, the same Relation to those Poles and that Equator, without any Difference. The Diurnal Motion therefore, which affords an obvious Foundation for the Invention of the Latitude of every Place on the Earth, affords us no such Foundation for the Invention of the Longitude of the same Places. Nor is it therefore an easy Problem, either astronomical or practical to discover the same.

As to the Methods hitherto tryed, they are either Celestial, or Terrestrial; and may be reduc'd to these Seven, Four that are *Celestial*, and Three that are *Terrestrial*.

(1) The Eclipses of the Moon.

(2) The Eclipses of the Sun.

(3) The

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- (3) The Eclipses of Jupiters Planets.
- (4) The Motion of the Moon.
- (5) The Variation of the Needle.
- (6) Clocks, or Watches.
- (7) The Log Line or Dead Reckoning.

First the Eclipses of the Moon are useful for the Longitude. For its Immersions into the Earth's Shadow, its nearest Distances to that Center, and its Emersions therefrom, are all at distinct and known Points of absolute time. So that where and when they can be nicely observ'd; and the Difference of the apparent times at every Meridian noted; the respective Longitudes of those Places may be thereby found in time; and by allowing 15 Degrees of the Equator to an Hour, may be found in Degrees also.

Secondly, in the same manner may the Eclipses of the Sun be made use of; especially as now improv'd by our great Astronomer Mr. *Flamsteed's*
Construction

Construction of them ; and as they will, we hope, be farther improv'd by Mr. *Whiston's* actual *Exhibition* of them, in his Instrument, just Published. Which Method, by the Difference of the apparent time of any Part of the Eclipse in different Places, gives the Difference of Meridians, or of Longitude in the like manner as before.

Thirdly, the Eclipses of Jupiters Satellits afford another like Method for the Discovery of the Longitude ; and that on the same Foundation with those of the Moon.

Fourthly, the Motion of the Moon, with its Distance from the Sun, or rather its Appulse to and Occultation of those fixed Stars that ly along its Course, is another remarkable Method for this purpose ; and is of the same Nature with the Eclipses of the Sun as to this matter.

These Four may justly be called *Celestial*, or *Astronomical* Methods of
B discovering

dicovering the Longitude, because they make use of the Celestial Bodies, or of the Stars in order to that End. The Three *Terrestrial* Methods are as follows.

5ly, The Variation of the Needle from the North is now, especially since Dr. *Halley's* noble Observations and Map thereto relating, become one Method for the Discovery of the Longitude; particularly in those Parts where that Variation is best known, and the North and South Position of its Lines are most remarkable. For by crossing the Meridians there, you also cross the Curves of equal Variation, and discover in some measure your Longitude thereby.

Sixthly, The Use of Clocks or Watches at Sea is another Method; and was attempted by the famous *Hugenius*. And indeed if they could be exactly kept to an even motion, and so shew the Hour at any one certain place at Land; the Comparison

parison of the Time known by that Clock or Watch, with the apparent time at the Ship known by the Sun or stars, or another Clock or Watch regulated by them, would discover the Longitude from the Place to which that first Clock or Watch was adjusted, in time, and so, as before, in Degrees also.

Seventhly, The Log-line and Dead Reckning, when all fails, is the last Remedy in this case ; and from thence the Seamen guess, as well as they can, by the Angle and length of their Course, what Longitude and Latitude, they are in : And when by Observation they find their Error in Latitude, they conclude upon a proportionable one in Longitude also. And so for want of a sure Guide, either Celestial or Terrestrial, they are forc'd to depend on this ; which yet is, as well as the rest, very uncertain and inaccurate.

For to come to the Reasons of the small Success of these several Methods.

As to the two first, the Eclipses of the Sun and Moon; to say nothing here of the slowness of the Moon's Motion, which renders any great degree of exactness impossible; or of the difficulty of Calculations and Construction, especially in the Sun's Eclipses; and of Observations in both: The single rareness of these Eclipses, which is not seldom made still rarer by cloudy Weather, renders them of very little use in Navigation.

As to the third Method, by the Eclipses of *Jupiter's* Planets; this must be own'd of much greater use: Since the quickness of their Motion, especially as to the innermost, makes the Moment of their Immersion into, or Emerfion from *Jupiter's* Shadow very distinct and nice; and their frequency, which is almost one for every Day, renders them fit for the constant uses of Navigation. Nor
have

have we hitherto had any other Method so useful at Land as this. Yet are there great Difficulties belonging to this Method; especially at Sea. The best Tables of their Motions are hitherto too imperfect to be at all times depended on, as to the exact absolute Time of their Celebration: And they require Telescopes of such a length as have not hitherto been manageable at Sea, in that state of Tossing and Agitation which Ships there are subject to: Which difficulties, added to the impossibility of seeing these Eclipses for about three Months every Year, when *Jupiter* is near the Sun, renders this Method at present of small use in Navigation.

Nor can the fourth Method, or the distance of the Moon from the Sun, with its Appulse to, or Occultation of those fixed Stars which lye along its course, give us the Longitude to sufficient exactness, for to say nothing here of the slowness of the Moon's Motion,

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Motion, the want of the utmost accuracy of even the place of some of these fixed Stars themselves, and of the Sun it self ; or of the necessity of the use of smaller Telescopes, even in this Case ; as well as of the trouble of the Calculation and Construction, which are lesser Difficulties here also ; 'Tis plain the Theory of the Moon, especially in some positions, is not exact enough hitherto for our purpose ; as not serving for this Longitude nearer than to two or three Degrees: whereas the Seamen want it within one Degree, or less. Tho' indeed it must be allow'd, that if the Moon's Theory could be once so far perfected, that its place might be with certainty calculated nearer than to two Minutes of a Degree, this would be a very useful Method in order to the Discovery of the Longitude at Sea. Which Improvement therefore of its Theory is a thing highly desireable in Astronomy.

We

We come now to the *Terrestrial* Methods, and to those difficulties which render them also incapable of discovering the Longitude, with that certainty, and to that degree of exactness which the purposes of Navigation require. Thus the Curve lines of the Variation of the Needle, which is the first *Terrestrial* Method, are of small use, because the Laws of that Variation are not yet brought to a sufficient certainty, notwithstanding the most useful endeavours of Dr. *Halley* in that Matter: The Neighbourhood of Iron Mines, of Iron, or of Loadstones themselves, does sometimes disturb the general Rules, and deceive the Observers of that Variation: The Position of those Curves, too far Eastward and Westward, in a great part of the World, renders this Variation useless as to any general Discovery of the Longitude: and even there where the Position of these Curves is the most advantageous

geous, as it is about the *Cape of Good Hope*, and a considerable way on both sides of it, yet is the distance of those Curves for the difference of one Degree of Variation, about 100 Geographical Miles, *i.e.* near two Degrees of a great Circle; and so this Method is incapable of shewing the Longitude very nicely in any Case whatsoever.

Thus the Second Terrestrial Method, by Clocks or Watches, tho' the easiest to understand and practice of all others, has been so long in vain attempted at Sea, that we see little Hopes of its great usefulness there. Watches are so influenc'd by heat and cold, moisture and drought; and their small Springs, Wheels and Pevets are so incapable of that degree of exactness which is here requir'd, that we believe the best Mechanicks have the least expectation from them in this Matter. Clocks govern'd by long Pendulum's go much truer: But then the difference of Gravity in different
La-

Latitudes the lengthening of the Pendulum-rod by heat, and shortening it by cold ; together with the different moisture of the Air, and the tossings of the Ship, all put together, are circumstances so unpromising, that we believe Wise Men are almost out of hope of Success from this Method also.

And as for the Log-Line, and Dead-Reckoning, which is the third Terrestrial Method, they were the known deficiencies of this common way, as alter'd by Storms, and Currents, and the Inaccuracies of the way it self, and of even the Latitude, as commonly taken; together with the too frequent and enduring cloudy Weather, when they can take no Latitude at all; which have occasion'd the Seamen to desire some other Assistance for the Discovery before us.

We now come to our last Business, *viz.* to give the World a short History of our own Proposal; from what occasions,

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casions, and by what steps this our Method was first discover'd, and has arriv'd at its present degree of Maturity. As to which matter, the Reader is to know, that somewhat above a Year ago, Mr. *Whiston* and Mr. *Ditton*, with some other common Friends, spent part of an Afternoon and the Evening together. Mr. *Ditton* took an occasion, among other common discourse, to observe to Mr. *Whiston*, that 'The nature of Sounds would
 ' afford a method, true at least in
 ' Theory, for the discovery of the
 ' Longitude ; since *The difference between the apparent time where the Sound is made, and where it is heard ; abating only the time for its diffusion, which was now well known ; is the difference of the Longitude of those two Places in time.* Mr. *Whiston* immediately own'd the truth of the Proposition, and added, ' That as to the Propagation of Sounds, he remembered to have himself plainly heard
 ' the Explosion of great Guns a-
 ' bout

‘bout 90 or 100 Miles, viz. when
the *French* Fleet was engag'd with
Ours, off *Beachy-head* in *Sussex*;
[which was *A. D.* 1690.] and
himself was at *Cambridge*; and that
he had been inform'd, that in one
of the *Dutch* Wars, the sound of the
like Explosions had been heard in-
to the very middle of *England*, at
a much greater distance. Upon
this, Mr. *Whiston*, when they part-
ed, told Mr. *Ditton*, that he took
the thing to be so considerable, that
tho it had been discoursed of in
mix'd Company, after an unguard-
ed manner, yet he look'd on it as
fit to be conceal'd; since no body
could tell what Improvements might
on farther Consideration be built
upon such a Foundation. Which
Advice Mr. *Ditton* follow'd; and ac-
cordingly desir'd and obtain'd the
Silence of those that had then heard
what had pass'd. This Proposition
about Sounds, and their distant Pro-
pagation,

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pagation, with respect to the Longitude, did upon this so fix it self in Mr. *Whiston's* Mind, and did occasion such Improvements there, that in less than two Days time he brought a small Paper to Mr. *Ditton*, containing a Scheme, how that Theory of Mr. *Ditton's* about Sounds might be reduc'd to Practice, and be actually apply'd to the discovery of the Longitude at Sea ; which was then not much unlike the former branch of the following Essay, only more imperfect: Which Scheme Mr. *Ditton* approv'd of. Soon after this Mr. *Ditton* imparted this Discovery to a very good Friend, belonging to the Admiralty, in order to gain farther light as to its practicableness at Sea ; and that proper Questions might by him be ask'd of Seafaring Men relating thereto, without any Suspicion ; which could not well be avoided if we our selves had ask'd them ; especially since the Notion was then
got

got abroad that we had a Project about the Longitude to propose to the World. The result of this Enquiry was, that those Sea-men our Friend enquir'd of, did not remember to have heard Sounds at Sea any whit near so far as the before-mention'd Examples shew'd they had been heard at Land; which difficulty put some stop to our Progress for a little while. However, at last, after farther enquiry, the final result was this, That tho' Sounds were not ordinarily either at Sea or Land heard very far, yet that was not at Sea more than at Land any certain Argument that they could not spread so far; because Sounds had been heard a full Degree at least, or 60 Geographical Miles over Sea, even without any extraordinary Contrivance, either at the sounding Body, or the Ear; both which were yet, for certain, capable of great improvements, in order to the enlargement of that distance.

distance. So that the Objection started against the spreading of Sounds at Sea seem'd to be in a manner over, and we at liberty to prosecute our Design, as before, of discovering the Longitude by means of it. About this time Mr. *Whiston* discover'd and propos'd a great Improvement of his own to this Method; *viz.* That the Guns which were to make the Explosions in the former Case, might also carry Shells, full of Powder, or such other combustible Matter as would take fire at the utmost Altitude; and thereby certainly and exactly exhibit the point of the Azimuth, and the Distance of the sounding Body; and so join the use of the Eye and Ear together for the same purpose. Tho' at the first he must own he suspected that the Apparent Diameter of that Light or Fire would in great distances be so small as not to be there visible. In this very juncture a day of extraordinary Fireworks

works happen'd [it was the Thanksgiving day for the Peace, *July* 7th, 1713.] the Contemplation of which, did much revive and encourage this Notion: and the certain Account he soon had that those Fire-works, nay, the small Stars into which the Rockets commonly resolv'd themselves, where plainly visible no less than 20 Miles, put an end to his doubts immediately; and made him very secure that such large Shells as might be fir'd at a vastly greater height, would for certain be visible for about 100 Miles; which he look'd on as nearly the limit of Sounds also, as to any purposes of Longitude. And this has been since abundantly confirm'd by experiments made by Mr. *Whiston's* own Directions. Thus on *Saturday, Aug.* 8th. last four several Rockets were by him and many others seen about 30 measur'd miles; and that so very plainly, that 'tis highly probable they might have been seen
at

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at least 10 if not 20 Miles farther, in a proper Elevation. Thus also the Light of a Ball of Fire of seven Inches diameter, which has been several times thrown up from a small Mortar at *Black Heath*, has been seen in several Counties at the distance of Fifty and Sixty, if not Seventy, measured Miles. This Improvement of Mr. *Whiston's*, which was also then for the main the same with the second Branch now contain'd in this Paper, was also approv'd of by Mr. *Ditton*, and agreed to as fit to be a part of the former Design for the Discovery of the Longitude at Sea. Mr. *Ditton* did farther add, for Improvement, a sure Method of Trigonometrical Calculation, to ascertain from the Observations the horary Difference of Meridians (and by consequence the Difference of Longitude in Degrees) between the Ship's Place, and that of Explosion ; without computing the Time of the Sound's

Sound's propagation : but since this Method is somewhat more operose than that which is propos'd hereafter, he chooses to omit it. He did also first observe that great Use of our Method at Land, in the Surveying of Countries, for the Perfection of Geography ; which was also readily taken notice of by Sir *Isaac Newton*, and afterwards by Dr. *Halley*, and that both of their own accord, upon our first communication of our Method to them. For when Matters were brought to so hopeful a Posture, and necessary Tables were preparing for the actual Practice of the whole Method, we began to think of intimating to the Publick, that we had a new Discovery, as to the Longitude, to propose to the World. Which we soon did, by our Letter inserted in the Paper call'd the *Guardian*, of *July* 14, and repeated by another in the same Author's Paper call'd the *Englishman*, of *December* 10.

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following : Having before communicated the matter to the illustrious *Sir Isaac Newton*, as we did afterward to those great Men, *Dr. Clarke* Rector of *St. James's*, *Dr. Halley* of *Oxford*, and *Mr. Cotes* of *Cambridge*. How far we profited by this Communication, and what their Opinions were concerning our Method, we need not say : because we do not give an Account here of every occasional Improvement, either of our own or others ; and because we now publish the entire Method, as it stands at present, to the whole World, for every one's open Judgment, and the farther Improvements of the skilful. Only so far their Opinions and Declarations appear to have been on our side, that upon hearing what they and we had to say, the Committee of the House of Commons, which was appointed to inquire into this matter, came unanimously to a Resolution in our Favour ; and the Legislature have there-

thereupon thought fit to pass an Act, appointing a noble Reward for such as shall discover a better Method than has been hitherto us'd for the finding the Longitude. Which Reward, whether we have any just Claim to, in whole or in part, we do hereby intirely submit to the Sagacity and Justice of those eminent Persons whom the Legislature has been pleas'd to intrust with the Tryal, Experiment, Judgment, and Determination of all such Proposals.

It must here be Observ'd, before we conclude, that this Method, as it was at first published, suppos'd the direct fixing of Hulls at Sea : which appearing very difficult in Practice, Mr. *Whiston* from several Hints he met with in conversing with Persons skill'd in Sea-Affairs, and his own Study of the Geometrical Part of managing of Ships, made another great Improvement, and contrived all so, that those *Hulls* might be spar'd,

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and any small *Stationary Ships* might suffice : and that instead of fixing such a Hull ; a Buoy, or Float, or Sea-Mark only should be really fix'd ; and the *Stationary Ship* should do no more than keep it self near the same : which it is easy to do within the distance here necessary. And this after such a manner, that if the Ship were at any time driven away, it should readily recover its former Station again ; as it now stands in this second Edition. It must also, in Justice, be observ'd, that when Mr. *Whiston* and Mr. *Ditton*, a little before the Sickness and Death of the latter, came to communicate this Improvement, which was generally approv'd of, to the Right Honourable the Earl of *Pembroke* ; who, as is most gratefully to be acknowledged, has all along shew'd a peculiar Readiness and Sagacity in bringing this Proposal to bear, and in clearing it of all such Difficulties as did incumber

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ber it ; His Lordship appeared to be already Master of it, and propos'd it to us as his own Thought. Nor is it fit to omit the other very considerable Information we at the same time received from his Lordship, of which we had some, but that very uncertain and imperfect Intimation before, *viz.* That it has actually appear'd upon Tryal, that the Ocean between *Europe* and *America* is no where above 300 Fathom deep, excepting near the Mouth of one of the great Rivers of the other Continent : where yet 'tis more likely the Strength of the Stream, by carrying the Line more oblique, occasion'd it to seem deeper than the rest than that it really was deeper in that particular Place. His Lordship also gave us Directions where to find this Account also ; tho' we have not hitherto been able to light on the Book refer'd to by his Lordship. Yet do we not at all doubt of the
Truth

Truth of the Experiment ; and do thereby find that our Buoys may therefore, in all Probability, be always fix'd by the sure Method of Anchors: which we were not before so well satisfy'd of. Which Observation is of great Use for the compleating our present Discovery.

We conclude all with our hearty Wishes as *Men*, that this our Design may tend to the common Benefit of Mankind : as *Britains*, that it may tend particularly to the Honour and Advantage of this our Native Country ; and as *Christians*, that it may tend to the Propagation of our Holy Religion, in its original Purity, throughout the World.

William Whiston, Humphry Ditton.

P R O-

PROBLEM.

To find the LONGITUDE
both at Sea and Land.

LEMMATA, or *Preparatory Propositions.*

I. **A**LL Sounds are propagated almost evenly ; and are observ'd to move in calm Weather very exactly 8 Measur'd Miles in 37 Seconds of Time : *i. e.* one Geographical Mile or Minute of a Degree in $5\frac{1}{3}$.

This is well known from the last and the most accurate * Observations

* *Philos. Transact.* N°. 247. Sir Isaac Newton's *Princip.* Edit. 2. p. 343, 344.

about

about the Velocity of Sounds, which are those of the Industrious and Skillfull Mr. *Derham*. Only a small Addition of Velocity is to be made, when a strong Wind carries the Sound with it, and Substraction when it opposes it; and that, as those Observations Shew, in the Proportion of the winds velocity to that of the Sound; which is hardly ever so great as One to Twelve.

II. The Sound of the greatest Guns may be heard by the Ear, duly assisted, if the Wind be favourable, or still, both by Sea and Land, at the least 100 measur'd, or 85 geographical Miles. In the open Sea also, the Point of the Compass may be nearly determin'd whence it comes.

This is very probable, as to the Distance, from many known Experiments*; wherein the Ear, even un-

* See *Philos. Transact.* p. 156, 201, 247.

assisted,

assisted, has heard such Sounds much farther. And if the Sound were increas'd by a sounding Board, which might prevent its diffusion upwards, and so spread it farther Horizontally on all sides; and if the Ear were assisted by a hollow Tube of Metal, of the shape of a Bell or Tunnel, apply'd thereto, this Proposition would soon be more indisputable. Nor is there any great Difficulty, as to the Point of the Compass, whence the Sound comes at Sea, where nothing can reflect or echo the same in any other than the true Angle.

III. The Distance of the sounding Body, where the Sounds are of the same Strength, and Tenor, and Circumstances, may, within some Latitude, be determin'd by the Ear, duly assisted, and frequently exercis'd in such Observations; even at very considerable Distances from the sounding Body.

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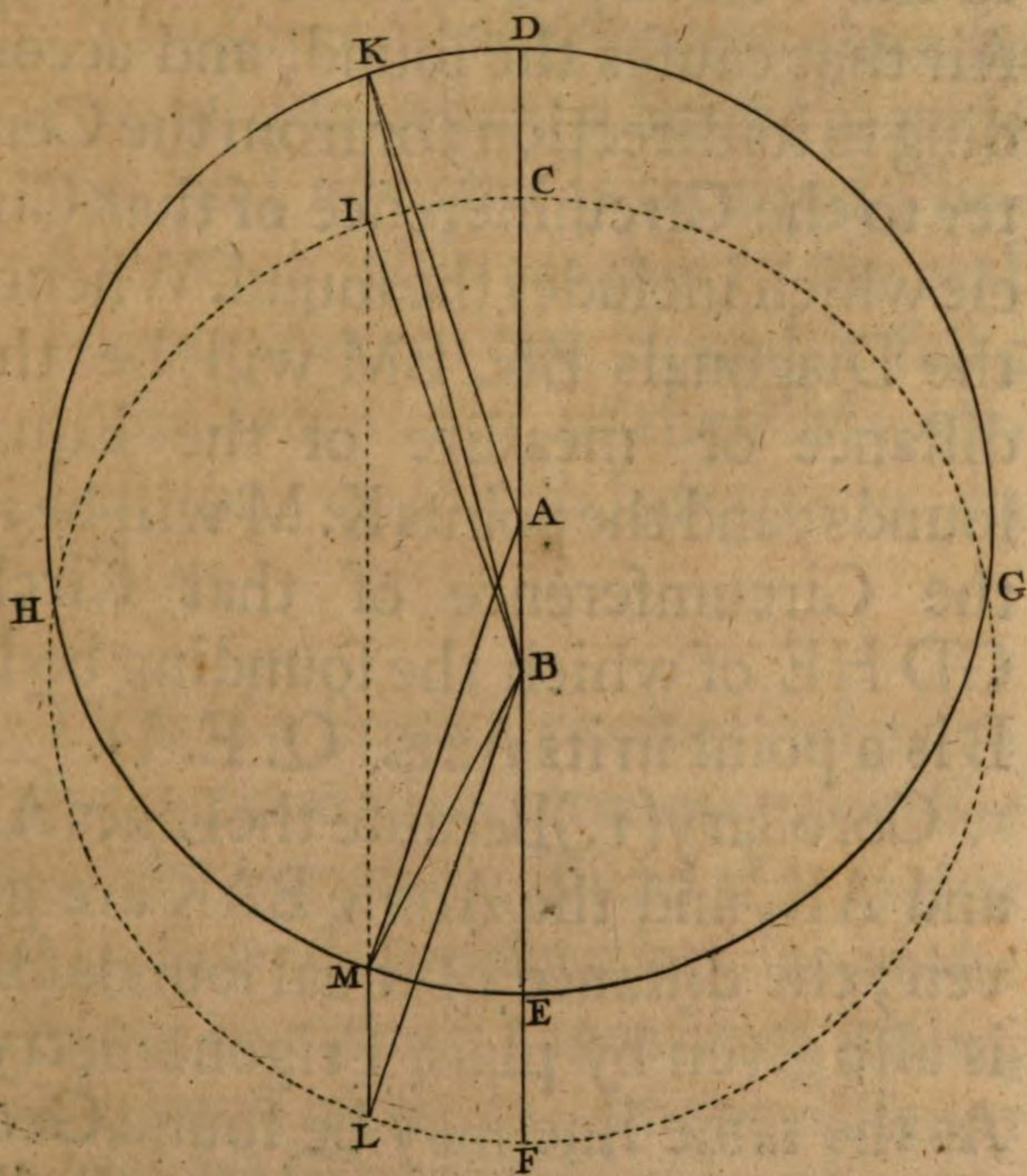
This appears from the obvious difference of the same Sounds at very different Distances at present ; which Sounds are in a duplicate Proportion of those Distances reciprocally. And from the great Improvements, Experiments made on purpose would probably afford us therein.

N. B. In order to determine accurately the Distance of a given Sound, there must be distinct Trials made, in an open Place, both by Sea and Land, in clear and in foggy Weather, with the Wind in all Positions, and of all Degrees of Strength ; and this at several Distances of the Hearers : but till that is done, we must leave this matter to the Ear alone.

IV. A strong Wind carries Sound along with it in a Circle ; where the Sounding Body is a Point in its Axis : and is more or less remote from its
Center,

Center, according as the Wind is greater or less.

This appears by the Demonstration following. Let the Proportion of the Velocity of the Wind, to the Velocity of the motion of the Air that causes the Sound, be as AB to AD .



E 2

Let

Let the two equal Circles GD HE, GCHF, be described upon the Centers A and B; and let any Line, as KL, be drawn Parallel to DE. KI will therefore be always equal to ML, or to the Velocity of the Wind, and according to its direction: as $AM = AK = BL = BI$ will be equal to the Velocity of the Motion of the Air that causes the sound, and according to its direction; or from the Center to the Circumference of that Circle which includes the sound. Whence the Diagonals BK, BM will be the distance or measure of the Equal sounds; and the points K. M will be in the Circumference of that Circle GD HE of which the sounding body B is a point in its Axis. Q. E. D.

Corollary(1.) Because the Lines AB and AK, and the Angle BAK are given; the distance of equal sounds BK is also given by plain Trigonometry. As the same line may be found Geometrically

metrically also by applying its length to a scale of equal parts.

Coroll. (2.) Two equal Circles, sliding one upon the other, according the direction of the Axis FD is the readiest way of solving this Problem, for the use of Seamen; as being so very easy in Practice.

V. The Interval of apparent time, in two places, where a Sound is excited, and where it is received; besides that which is due to the real propagation of the Sound it self; is the Difference of their Meridians, or of their Longitude in Time.

Thus if a Sound, excited just at 12 a clock at one place, comes to another after the very same Time that is due to the Sounds propagation, as at the distance of about 13 measured Miles, one minute after 12. At the distance of 26 such Miles, two minutes after 12.
&c.

&c. 'tis evident the places are under the same Meridian, and have no difference of Longitude. But if it be heard sooner or later than those times, the Difference is what answers to the Temporary difference of their Meridians, or of Longitude, Westward or Eastward: and so is a sure indication of the same. As is very obvious on a little consideration; and as we shall shew presently by example.

VI. A Moderate Mortar, with a Moderate Charge of Powder, is able to cast a projectil near two measur'd miles, or 10000 English feet in perpendicular height.

This appears by that known * Theorem in the Art of Gunnery, which demonstrates, that the utmost Altitude is always equal to half the utmost Random of the same Gun and

* Halley ap. *Transact. Philosoph.* N^o 179. Mr. Anderson's *Gunn. passim.*

Powder:

Powder : which utmost Random, of such a Mortar, with a competent charge of Powder, is known to be near four measur'd miles, or 20000 feet.

And Since we have already tryed a very small Mortar, and find that with one Pound and an half of strong Powder it casts up a Shell of above 20 Pound weight not much short of a measured Mile high, there is no reason at all to doubt of the Truth of this Proposition.

N. B. That it appears by the same way that the largest Great Guns, with their largest charge of Powder, may probable be able to cast a Projectil twice so high. But because the charges and trouble are in such cases much greater ; and it is uncertain whether the advantages will be proportionably augmented, we choose to speak moderately ; and to propose nothing here but what is for certain cheap, practicable, and advantageous ; and leave those
those

those more surprizing heights, to the consideration of the publick afterward : Only with this observation, that the Altitude will ever be as the Squares of the Velocity, with which the Projectil is thrown. *i. e.* With double and triple velocity, the Altitude will be four and nine times as great as before respectively ; and so for ever.

VII. The time of the Ascent or Descent of such a Projectil ; without the consideration of the resistance of the Air ; (which in the case of lead bullets, iron shels, or the like dense bodies, is but very small, and in Wood not very great ;) is 25" : and is always the same in the same height.

This appears from the known Velocity of descending or ascending bodies *, which fall or rise 16¹/₂ Eng-

* Ubi Supra.

lish Feet in one second of time ; and by consequence 6400 Feet in 20". and 10000 in 25". those lines of descent or ascent being ever as the Squares of the Times.

VIII. Gunpowder may be discharged, or combustibile matter set on Fire at that utmost height.

This all that deal in Rockets, Bombs and Mortars do very well know. It being the great business of their Art to proportion the Match or Fusee to any particular time when it shall give Fire ; which may as well be always adjusted to 20" or 25" as to any other number. Nor indeed is it impossible to contrive all so, that the very beginning of the descent shall be immediately instrumental in that matter, and thereby render the Experiment more exact and infallible.

IX. Fire or Light, if it be strong enough, and 6400 Feet high, will be visible, in the night time, when the Air is tolerably clear, about 100 measured, or 85 Geographical Miles: *i. e.* one whole degree, and 25 minutes of a great Circle, from the place where it is, even upon the surface of the Sea. And if it be 10000 feet high, it will be visible 123 measur'd, or 106 Geographical miles, in the same Circumstances.

This is easily deduced from the Tables of Tangents and Secants, applyed to our Earth; as will appear presently. Only it may be noted that the Refraction of Light out of the somewhat thinner Air above, into the somewhat thicker Air beneath, increases this distance a little; as also that an Eye upon the Mast of a Ship will see such Fire or Light about 10
Miles

Miles farther than one on a Level with the Surface of the Sea ; as will appear presently also.

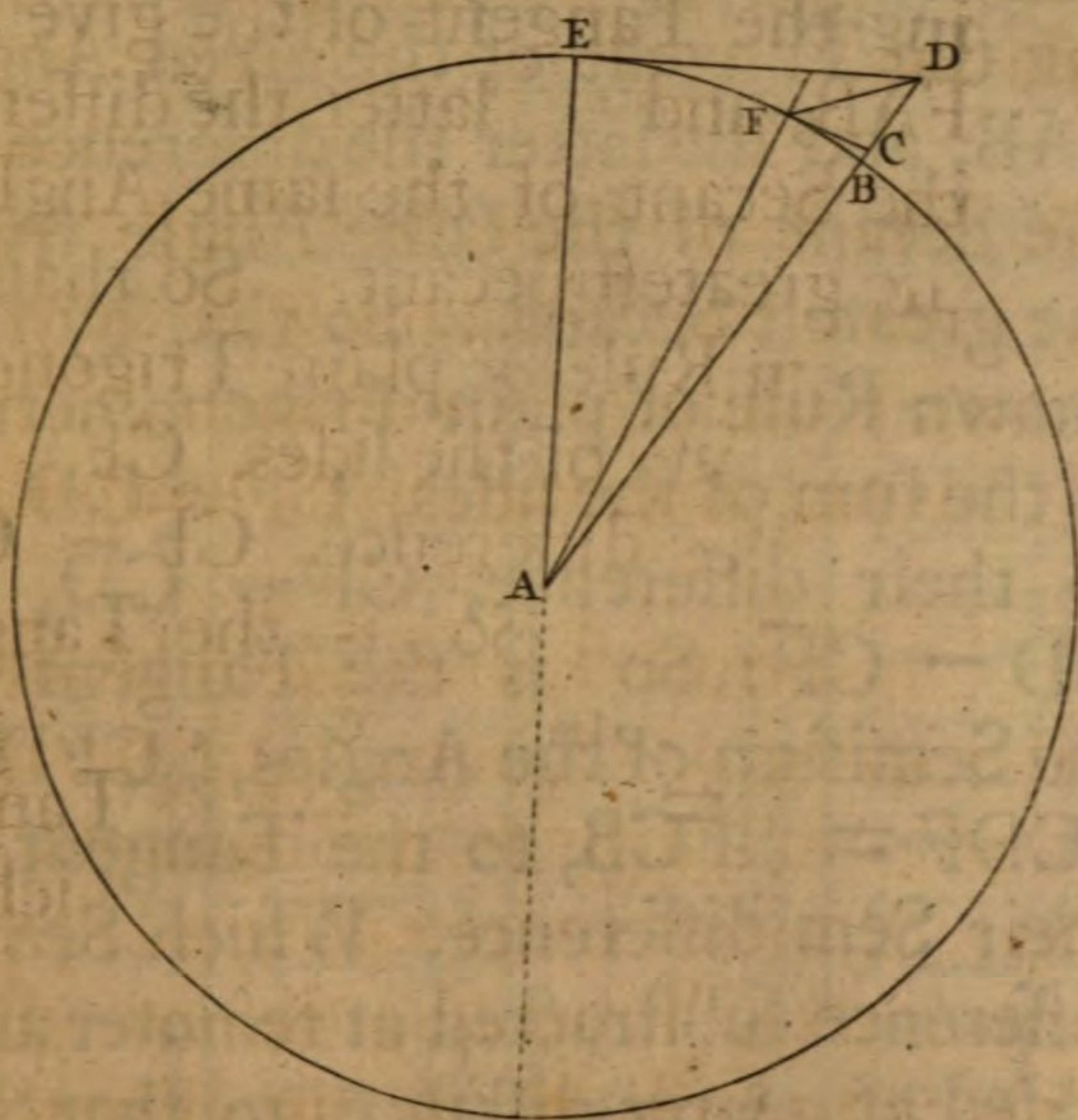
N. B. That the Distances this Fire or Light can be seen, abating the consideration of the Atmosphere, are nearly in a subduplicate proportion of the Altitudes ; and so at twice the greatest height already mentioned, to which yet we have observed Projectils may be thrown, this distance will be larger in the proportion of 10 to 7 ; *i. e.* about 176 measured, or 151 Geographical Miles ; even without the allowance for refraction, or for the elevation of Mountains, whereon such Mortars or Guns may be plac'd : both which, when allowed for, will imply, that 'tis possible, if the light be strong enough, to extend this distance to full 200 Geographical Miles, or minutes of a great Circle. A vast extent this ! and capable of affording proportionably vast advantages

to Mankind, upon the present foundation!

X. The Angle such fire or light is seen above the Horizon will very exactly discover its distance; as will an easy observation its Azimuth.

The former branch is evident from the nature of a Sphere, with the usual Tables of Tangents and Secants: and may thus be computed by plain Trigonometry. Supposing the eye of the Spectator placed at the surface of the Sea; and not considering the very small difference by the refraction.

Let A represent the Earth's Center, BD the length of the Secant of 1° . $25'$. or 1° . $46'$ above the Radius; *i. e.* 6400 or 10000 feet. ED the Tangent of the same Angle. CB the length of the Secant above the Radius, at any lesser Angle, as BAF. and CF the Tan-



Tangent of that last Angle. 'Tis evident that the Angle DFC is the elevation of the fire or light above the horizon at any given Point F. and that in the plain Triangle DCF the Angle DCF is given, equal to a right Angle, and to the Angle FAB. FCB is its complement ; and equal to the sum of the remote Angles CFD, and CDF. The including sides also CF and

and CD are given ; the former being the Tangent of the given Angle FAB, and the latter the difference of the Secant of the same Angle from the greatest Secant. So that by the known Rule of plain Trigonometry, as the sum of the sides, $CF + CD$, is to their difference, $CF - CD$, or $CD - CF$: So is the Tangent of the Semisum of the Angles, $\frac{1}{2} CFD + \frac{1}{2} CDF = \frac{1}{2} FCB$, to the Tangent of their Semidifference. Which Semidifference subtracted at remoter and added at nearer distances to that Semisum ; gives the Angle sought CFD. Q E. I.

According to this Rule the following Tables are made to every Minute, or Geographical Mile ; for the ease of all that may use this Method, and may desire some exactness therein.

Table

Table the first, for the utmost Altitude of 6400 feet, and 40".

Miles distance	Angle above the Horizon.	Miles distance.	Angle above the Horizon.
1	46—25	29	1—50
2	27—42	30	1—46
3	19—16	31	1—41
4	14—40	32	1—37
5	11—50	33	1—33
6	10—20	34	1—28
7	9—0	35	1—24
8	7—55	36	1—20
9	6—50	37	1—17
10	5—55	38	1—14
11	5—20	39	1—12
12	4—54	40	1—10
13	4—30	41	1—7
14	4—8	42	1—4
15	3—52	43	1—1
16	3—37	44	0—59
17	3—23	45	0—57
18	3—11	46	0—55
19	3—0	47	0—53
20	2—50	48	0—51
21	2—41	49	0—49
22	2—33	50	0—47
23	2—25	51	0—45
24	2—18	52	0—43
25	2—12	53	0—41
26	2—6	54	0—39
27	2—1	55	0—38
28	1—55	56	0—36

Miles

Miles distance.	Angle above the Horizon.	Miles distance.	Angle above the Horizon.
57	0—34	72	0—14
58	0—32	73	0—13
59	0—31	74	0—12
60	0—30	75	0—11
61	0—28	76	0—9
62	0—26	77	0—8
63	0—25	78	0—7
64	0—24	79	0—6
65	0—23	80	0—5
66	0—21	81	0—4
67	0—20	82	0—3
68	0—19	83	0—2
69	0—18	84	0—1
70	0—17	85	0—0
71	0—15		

Table the second, for the utmost
Altitude of 10000 feet, and 50".

Miles distance.	Angle above the Horizon. ° "	Miles distance.	Angle above the Horizon. ° "
1	58—32	10	9—12
2	39—14	11	8—22
3	28—23	12	7—40
4	22—11	13	7—3
5	18—4	14	6—32
6	15—11	15	6—5
7	13—16	16	5—42
8	11—41	17	5—21
9	10—21	18	5—2

Miles

for the Longitude. 49

Miles distance.	Angle above the Horizon. °	Miles distance.	Angle above the Horizon. °
19	4—46	51	1—24
20	4—30	52	1—21
21	4—16	53	1—18
22	4—4	54	1—15
23	3—53	55	1—12
24	3—42	56	1—10
25	3—32	57	1—8
26	3—22	58	1—6
27	3—14	59	1—4
28	3—6	60	1—2
29	2—59	61	1—0
30	2—52	62	0—58
31	2—46	63	0—56
32	2—40	64	0—55
33	2—35	65	0—53
34	2—30	66	0—52
35	2—25	67	0—50
36	2—20	68	0—49
37	2—15	69	0—47
38	2—10	70	0—46
39	2—5	71	0—44
40	2—1	72	0—43
41	1—57	73	0—41
42	1—53	74	0—40
43	1—49	75	0—38
44	1—45	76	0—36
45	1—42	77	0—34
46	1—39	78	0—33
47	1—36	79	0—31
48	1—33	80	0—30
49	1—30	81	0—28
50	1—27	82	0—27

G

Miles

Miles distance.	Angle above the Horizon. ° "	Miles distance.	Angle above the Horizon. ° "
83	0 — 26	95	0 — 11
84	0 — 24	96	0 — 10
85	0 — 23	97	0 — 9
86	0 — 21	98	0 — 8
87	0 — 20	99	0 — 7
88	0 — 19	100	0 — 6
89	0 — 18	101	0 — 5
90	0 — 17	102	0 — 4
91	0 — 15	103	0 — 3
92	0 — 14	104	0 — 2
93	0 — 13	105	0 — 1
94	0 — 12	106	0 — 0

N. B. It appears by these Tables that the distance will never be less exact in this Method than is the Observation of the Altitude ; since one Mile here never corresponds to less than one Minute ; but that generally the distance is much more exact than the Observation : Since one Mile commonly corresponds to considerably more than one minute ; nay at very near distances to more than one whole Degree ; as is evident by inspection. As for the observation

for the Longitude. 51

Observation of the Azimuth, 'tis too easie to need any demonstration.

N. B. If the Eye be elevated above the surface of the Sea, it will see the fire or light farther ; according to the following Table.

Miles distance.	Elevation in feet.
1	1
2	4
3	8
4	15
5	23
6	34
7	45
8	57
9	71
10	88
11	107
12	128

XI. If the fire or light be rendred compleatly visible during the intire time of the ascent or descent, as in the ordinary Sky-rockets, its Distance may be exactly determin'd also from the time it appears above the Horizon, by the

use of the following Tables, even without the knowledge of the Angle of Elevation.

A Table of the number of feet that Bodies fall or rise, as far as 25". of Time.

"	feet.	"	feet.
1	16,1	$\frac{1}{2}$	2930
$\frac{1}{2}$	35,4	14	3156
2	64,4	$\frac{1}{2}$	3381
$\frac{1}{2}$	100	15	3622
3	145	$\frac{1}{2}$	3864
$\frac{1}{2}$	193	16	4122
4	259	$\frac{1}{2}$	4379
$\frac{1}{2}$	320	17	4653
5	402	$\frac{1}{2}$	4927
$\frac{1}{2}$	483	18	5216
6	580	$\frac{1}{2}$	5506
$\frac{1}{2}$	676	19	5812
7	789	$\frac{1}{2}$	6118
$\frac{1}{2}$	902	20	6440
8	1030	$\frac{1}{2}$	6762
$\frac{1}{2}$	1160	21	7100
9	1294	$\frac{1}{2}$	7438
$\frac{1}{2}$	1442	22	7792
10	1610	$\frac{1}{2}$	8147
$\frac{1}{2}$	1771	23	8517
11	1948	$\frac{1}{2}$	8887
$\frac{1}{2}$	2125	24	9273
12	2318	$\frac{1}{2}$	9660
$\frac{1}{2}$	2512	25	10062
13	2721		

N. B.

for the Longitude. 53

N. B. That if we allow in this Table the odd 40 and 62 feet, over against the greatest Altitude, of 20". and 25". for the small resistance of the Air, we shall then have the even Numbers 6400 and 10000 feet for the real perpendicular Altitudes respectively ; as we have all along suppos'd them to be.

A Table of the Excess of the Secants in Feet, above the Earth's Semi-diameter, as far as 1°. 46".

'	feet.	'	feet.
1	1	16	227
2	4	17	256
3	8	18	288
4	15	19	321
5	23	20	357
6	34	21	393
7	45	22	430
8	57	23	470
9	71	24	512
10	88	25	556
11	107	26	601
12	128	27	647
13	151	28	695
14	174	29	745
15	199	30	798

'	feet.	'	feet.
31	853	65	3755
32	909	66	3870
33	968	67	3988
34	1026	68	4118
35	1088	69	4229
36	1151	70	4353
37	1216	71	4479
38	1283	72	4608
39	1352	73	4735
40	1422	74	4866
41	1493	75	4998
42	1569	76	5132
43	1642	77	5269
44	1720	78	5407
45	1800	79	5546
46	1882	80	5687
47	1963	81	5830
48	2047	82	5974
49	2134	83	6121
50	2222	84	6271
51	2312	85	6422
52	2404	86	6573
53	2497	87	6726
54	2592	88	6882
55	2688	89	7039
56	2787	90	7199
57	2887	91	7360
58	2991	92	7522
59	3093	93	7686
60	3198	94	7852
61	3305	95	8020
62	3415	96	8190
63	3526	97	8362
64	3639	98	8536

'	feet.	'	feet.
99	8611	103	9429
100	8887	104	9614
101	9066	105	9799
102	9246	106	9986

N. B. The Rule for Practice is this : Observe the Number of the Seconds of Time that you see the Fire or Light, either ascending or descending, in the former Table ; with its corresponding Number of Feet. Take this Number of Feet out of the entire Number, and keep the Remainder. For where that Remainder is found in the latter Table, you will find the true Distance over against it. *e. g.* Suppose the Light or Fire is observ'd to take up 12". or a fifth Part of a Minute, in its visible Ascent or Descent. The corresponding Number of Feet in the former Table of 6400 Feet for 40". is 2318, which deducted from 6400, leaves 4082, for the Difference : Which Number in the other Table

Table corresponds to about 68'. and shews that the real Distance sought, is about 68 Minutes, or Geographical Miles. And in the other Altitude of 10000 Feet for 50". the corresponding Number of Feet is the same, 2318 ; which deducted from 10000, leaves 7682, for the Difference : Which Number, in the other Table, corresponds to about 93'. and shews that the real Distance is in that Case 93 Minutes, or Geographical Miles. The Demonstration is easy from the former Scheme. For $DB - DC = CB$, and so $DA - DC = CA$. or the Difference of the largest Secant, and of any Part of it visible in another Horizon, as at F, is equal to the Secant of that Angle DAF, or of the Arch BF, which is the Distance required. Only if the Bottom of the Atmosphere be too thick to permit the Light or Fire to be seen to any certain Altitude,

tude, allowance must be made for the same, in the use of these Tables.

XII. When a Sound and a Light are made at the same Place, either at the same time, or at any given Interval ; the Distance of such Sound and Light from the Auditor or Spectator may be exactly determin'd.

For if they are made at the very same time, the Difference of the Velocity of Light, which is, physically speaking, instantaneous, and of Sound, which goes Eight measur'd Miles in Thirty seven Seconds, will, with great Exactness, determine that Distance. And if there be a given Interval between them, it is easily allow'd for.

N. B. But for the greater ease and readiness of knowing this Distance, wherever the Ball of Light or Fire is

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visi-

58 *A New Method*

visible, either all the way up and down, or even barely up or down; the following Tables, deriv'd from the two foregoing, will, by Inspection, immediately shew it, to every half Second of Time; both for the utmost Altitude of 6400 feet, and 40". and of 10000 feet, and 50". in case the Time be reckon'd half that which passes from the ascent of the Body above the visible Horizon, till its descent below it again; without any farther Trouble.

A Table of Miles distance from the Explosion, for the Altitude of 6400 Feet and 40". as also for 10000 Feet and 50".

40". "	Miles distant.	40". "	Miles distant.
$\frac{1}{2}$	85	4	83
1	85	$\frac{1}{2}$	83
$\frac{1}{2}$	85	5	82
2	85	$\frac{1}{2}$	82
$\frac{3}{2}$	85	6	81
3	84	$\frac{1}{2}$	81
$\frac{1}{2}$	84	7	80

40'.

for the Longitude. 59

40". "	Miles distant.	40". "	Miles distant.
$\frac{1}{2}$	79	14	60
8	78	$\frac{1}{2}$	58
$\frac{1}{2}$	77	15	56
9	76	$\frac{1}{2}$	53
$\frac{1}{2}$	75	16	50
10	73	$\frac{1}{2}$	47
$\frac{1}{2}$	72	17	44
11	71	$\frac{1}{2}$	40
$\frac{1}{2}$	70	18	36
12	68	$\frac{1}{2}$	30
$\frac{1}{2}$	66	19	26
13	64	$\frac{1}{2}$	18
$\frac{1}{2}$	62	20	00

50". "	Miles distant.	50". "	Miles distant.
$\frac{1}{2}$	106	$\frac{1}{2}$	99
1	106	10	98
$\frac{1}{2}$	106	$\frac{1}{2}$	97
2	106	11	95
$\frac{1}{2}$	106	$\frac{1}{2}$	94
3	106	12	93
$\frac{1}{2}$	105	$\frac{1}{2}$	92
4	105	13	91
$\frac{1}{2}$	105	$\frac{1}{2}$	89
5	104	14	88
$\frac{1}{2}$	104	$\frac{1}{2}$	87
6	103	15	86
$\frac{1}{2}$	103	$\frac{1}{2}$	84
7	102	16	82
$\frac{1}{2}$	102	$\frac{1}{2}$	80
8	101	17	78
$\frac{1}{2}$	101	$\frac{1}{2}$	76
9	100	18	74

H 2

50".

50". "	Miles distant.	50". "	Miles distant.
$\frac{1}{2}$	72	22	50
19 $\frac{1}{2}$	69	$\frac{1}{2}$	46
$\frac{1}{2}$	66	23 $\frac{1}{2}$	41
20 $\frac{1}{2}$	64	$\frac{1}{2}$	36
$\frac{1}{2}$	61	24 $\frac{1}{2}$	29
21 $\frac{1}{2}$	58	$\frac{1}{2}$	20
$\frac{1}{2}$	54	25	00

N. B. If this Method by the Time be made use of in the greater, and that by the Altitude above the Horizon in the lesser Distances, the Measures will be the most exact.

N. B. This Method by the Time is very easy for Practice; because it requires only the counting of a few Seconds or half Seconds. Nor is that Inaccuracy which appears at near Distances of any great consequence; because the very guess at the Altitude will there sufficiently correct it; and because near the place of Explosion there will be little occasion for any nice Observations at all.

N. B. This Method, if it reach to ascent and descent also, is also exceeding

ceeding useful ; because it will shew the Altitude and Distance, even when Clouds intercept the sight of the Shell near the top, as will sometimes happen : since the Time between the first and last sight of the Shell in its ascent above and descent below the Horizon, on which the whole depends, is not affected by it ; *i. e.* wherever there is any space between the Clouds and the visible Horizon : otherwise there is no room for this Observation.

N. B. But because the longer time the combustible Matter is in burning the lesser must be its Light, the best way of all seems to be that of making it take Fire some time before it comes to the utmost Elevation, and to make it burn some time after. This will serve every Intention as near as may be. It will give the Distance by the Elevation every where : and also by the Time in remoter

moter Distances, where that last Method is chiefly useful.

XIII. If the Longitude and Latitude of one Place be known, and the Distance and Position of another be also known; the Longitude and Latitude of this other Place is known also.

This is too obvious to need a Demonstration; and may be easily shew'd on a Map, with a Pair of Compasses, apply'd to the Scale of that Map.

XIV. If the Longitude and Latitude of one Place be known, and its Distance from another be known also, and the Longitude of that other Place be otherwise known, its Latitude is thereby known. And if its Latitude be otherwise known, its Longitude is thereby known also.

This

This is also too obvious to need a Demonstration ; and may be shew'd on a Map, as well as the foregoing.

XV. Buoys, Floats, or Sea-marks, near which Ships may keep their Stations, may be intirely fix'd at Sea in all ordinary Cases, by Anchors ; and in extraordinary Cases, where the Ocean is vastly deep, they may be nearly fix'd by Weights let down from them quite through the upper Currents into the still Waters below, as near as possible to the Bottom.

This Matter belongs to Tryal and Experiments, and is not to be here particularly demonstrated. Only we may observe, that the lower Parts of the Waters in the Ocean are commonly found to be free from the Currents and Motions of the higher Parts ; and that the Method by which those very Currents are discover'd, is

is no other than by thus letting down the Lead far below them ; which, tho' it touch not the Bottom, yet makes the Boat out of which the Lead is thrown, in the Words of an Eye-Witness, * *ride as firmly as if it were fastened by the strongest Cable and Anchor to the Bottom.*

N. B. If any Current or strong Wind does, in some measure, carry away such a Buoy, with any ordinary Leads, or Weights, care is to be taken that the Cord or Chain be upward as small, and make as little Resistance to the flowing Water as possible ; and that the same Cord or Chain with its Weights or Leads below, be as large and cumbersome, and make as great Resistance to the still Water below, as possible : that so the Motion of the Buoy may be insensible. Note also that in case there appear still some Motion in

* *Philos. Transf. No. 36. Abridg. Vol. 3. p. 555, 556.*

the Buoy, the Mariners are nicely to observe its Velocity and Direction; and at convenient Seasons to bring it back again, as near as possible, to its original Station.

N. B. This Buoy, Float, or Sea-Mark may be a very strong Circle of Planks, with a small but strong Mast in the middle, of about 23 Feet high, supported by great Cables, as Braces on every side, and a bright Sphere and Lanthorn at the top, for its more easy and remote Discovery from the Ship.

N. B. This Buoy will be seen from the Mast of a Ship 88 Feet high, by the former Table, *pag.* 51. at the distance of full 15 Miles, or any where within a Circle of 30 Miles Diameter, which is near 100 Miles in Circumference.

N. B. Since the Art of Navigation, and common Practice at Sea assure us, that a Ship can sail above two Points towards the Wind; nay,
I by

by plying in an indented Manner to Windward, can directly sail against it ; And since such a Buoy will be so far visible ; it is evident, that when there is danger of a Storm, the Stationary Ship may go 15 Miles to Windward ; and that then no Storm need drive it out of sight of that Buoy, but such an uncommon one as shall overcome the Ships attempt to sail to Windward 30 Miles, or to its attempt to keep within a Circle of 30 Miles in Diameter. However,

N. B. If any prodigious Storms should sometimes drive it out of sight of the Buoy, yet will not this be any very great or long Inconvenience : because, as soon as the Storm is abated, they can immediately sail into and along the known Parallel of the Buoy, and so recover their former Station near it. Again,

N. B. Since it now appears by direct Observations, as has been already

dy hinted, that there are few or no Places of the Ocean too deep for casting Anchor, 'tis very probable there may be little or no occasion for any other way of fixing these Buoys than that by Anchors ; which is the sure, plain, and most obvious Method for that Purpose.

N. B. These Buoys may be placed in proper Stations as to Latitude, by the known Methods of observing the Latitude ; and as to Longitude, by the Eclipses of the Sun, or Moon, or of *Jupiter's* Planets, or by the Moon's Appulse to fixed Stars ; or rather by an actual Mensuration of Distances on the Surface of the Sea by Trigonometry, just as *Monfieur Picard* and *Cassini* measur'd the Length of a Degree of a great Circle on the Land ; while the Lights to be thrown up from the Ships will afford the same Advantage that any elevated Mark does at Land, and while the vastly greater Length of a Basis or measur'd Line

on the Shore ; the vastly greater Distances of the Ships ; and the much greater Evenness of the Surface of the Sea than of the Land, do give us hopes of more Exactness in this Way of Mensuration than in any other.

N. B. By the same Method, if done with sufficient Accuracy, we may also hope to discover the Quantity of a Degree in all sorts of great Circles, and perhaps more exactly than even Monsieur *Picard* or *Cassini* have been able to do : because we may hereby actually measure a much larger Portion of such great Circles than they could ; especially if the Sound can also be heard at such great Distances, and compar'd with the other Trigonometrical way of Mensuration. Which Advantage of this Method is in it self very considerable. Nor is there any Reason why it may not be put in Practice at Land also, for the same Purpose ; especially on large Continents.

XVI. If the Altitude of the Sun, at the best Advantage, can be taken within four Minutes of a Degree at Sea or Land ; the time is thereby determined to about half a Minute : if to two Minutes of a Degree, the time is determin'd to about a quarter of a Minute, even in our Latitude ; while nearer the Equator the like Limits determine the Time still more exactly.

This the Astronomers well know : and any that observe in common Quadrants how an Hour, in the middle between Noon and either Morning or Evening, contains usually about 7 or 8 Degrees of Altitude ; while no less than 15 Degrees makes an Hour upon the Equator, will easily agree to this Proposition.

XVII. The best time for the exact Discovery of the Hour at Sea, and
of

of adjusting all Watches or Movements to shew the same afterwards, is that of the rising and setting of the Sun ; that is, in case Allowance be made for the Horizontal Refraction of his Rays ; but not otherwise.

For if the time while the whole Body of the Sun is rising or setting, which may be very nicely observ'd at Sea, be added at Night to, and subtracted in the Morning from, the Time that any Table of its rising and setting, or a particular Trigonometrical Calculation, does determine ; the Sum in the first, and Difference in the second Case will give the true Time when the Sun's Center will appear to be in the very Horizon. And this because the Sun's Horizontal Refraction is observ'd to be very nearly equal to his apparent Diameter.

N. B.

for the Longitude. 71

N. B. The exact time of the Sun's rising and setting, from Six a Clock, at all Declinations, and in all Latitudes, is found by the following easy Rule of Trigonometry.

As the Radius :

To the Tangent of the Latitude :

So is the Tangent of the Declination :

To the Sine of the Hour from Six.

For an Example. Let us compute for the Longest Day, in the Latitude of $51^{\circ}.30'$.

Rad. 90° . Log. 10.0000000.

Tang. Lat. $51.30'$. Log. 10.0993948.

Declin. 23.29 . Log. 9.6379563.

Sin. Log. 9.7373511. = $33^{\circ}.6'.24''$.

i. e. = $2^h.12'.28''$. Q. E. I.

Note also that the Amplitude cannot be exactly taken, even at Sea, without the like Allowance for Refraction. And the Difference of Amplitude, when the first Edge of the Sun touches, and the last leaves the
Hori-

Horizon, is to be added or subtracted in this Case, to or from that when it appears to be half set ; in order to obtain the Sun's true Amplitude : as well as we added or subtracted the Difference of Time before, for the exact Adjustment of the true Moment of its rising and setting.

The Solution of the Problem.

Let a Mortar or great Gun, with a Shell that will take Fire at its utmost Altitude, be discharg'd perpendicularly 6400 or 10000 Feet high above the Surface of the Sea, every Night exactly at 12 a-Clock, and in foggy Weather the next Hour after the Fog is clear'd up also, at all convenient Distances and Situations, and from known Places. This Discharge will, by the Distance and Point of the Compass of its Sound, nearly give the Longitude and Latitude to all Places or Ships within the hearing

ing thereof : And it will, by the same Distance and Azimuth of its Light or Fire, exactly give the same Longitude and Latitude to all Places or Ships within the Sight thereof ; according to the foregoing Lemmata. Q. E. I.

For Example : Let us suppose a Ships Station to be fixed in a known Place, 30 Degrees more Westward than the Meridian of *London* ; and that every Midnight its Mortar or Great Gun is discharged, as before ; and that a Ship sailing by at 54'. 40". after Eleven, sees the Fire or Light 30'. above the Horizon ; *i. e.* by the foregoing Table for 6400 Feet Altitude and 40". at 60 Minutes, or Geographical Miles distance. It was therefore 12 a Clock at the Hull, when it was only 11 h. 55'. at the Ship. So that the difference of Time is 5'. and the difference of Longitude upon the Equator 1°. 15'. and the Ships Longitude from the Meridian

of *London* is hereby known to be $31^{\circ} 15'$. Westward.

Suppose also that the Weather be such that only the Sound can be heard, and that it proves to be so weak as to be justly esteem'd 65 measur'd Miles distant. This Distance answers to about $5'$. of Time, for the Interval of the Propagation of the Sound : which therefore, if it be heard just at 12 a-Clock at the Ship, will imply that when the Explosion was made, it was at the Ship only $55'$. past 11, the same Moment that it was full 12 at the Hull ; and that therefore the difference of Meridians is the same as before, *viz.* $5'$. in Time, or $1^{\circ} 15'$. upon the Equator, Westward.

Suppose farther, that the Light be seen at the same time that the Sound is heard ; with no other than the small difference of the slowness of the Sound, in comparison of the instantaneous Motion of the Light ;
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and that the difference of Time between the most elevated Appearance of the Light and the hearing of the Sound; (which may be easily and exactly observ'd by any tolerable Movement whatsoever, or by a Pendulum, that vibrates half Seconds :) be found to be $4'. 40''$. or, which is all one, that the intire difference of the Explosion made, and of the Sound heard, be $5'$. in Time. This difference will imply the distance of the Ship from the Explosion to be 65 measur'd Miles. And if the Sound is heard at the Ship $54'. 40''$. after Eleven, the difference of Longitude upon the Equator will still be $1^\circ. 15'$. and the real Longitude from *London* will be $31^\circ. 15'$. Westward, as before.

If the Azimuth of the Fire or Light be also observ'd, take with your Compasses from your Scale the true distance, 65 measur'd Miles, and set it from the place of the Hull, on the true Angle, in any

large Map or Sea-Chart. This will determine the very Point where the Ship is, both for Longitude and Latitude. The same thing may be done for the Sound, in case the Point of the Compass be observ'd also.

If the Latitude of the Ship be known, take the known distance, either by the means of the Light or Fire seen, or, if the Weather be too Foggy for that, of the Sound heard ; and let it cross the known parallel of Latitude in the Chart ; and this will determine the Longitude. The like is to be done for the Latitude, were the Longitude first known. But that not being the usual Case, it needs not be farther insisted on. Nor need we shew how all this may be done by Calculation also, since those that understand any thing of Navigation cannot be to seek therein.

N. B. It is found by Experience, that the Light of the Moon is too faint to give much Disturbance to
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the Light or Fire here made use of. Otherwise an Explosion ought also to be made for several Nights before the Full, the next Hour after the Moon is set ; and for several Nights after the Full, the next Hour before the Moon is risen ; besides the ordinary ones at Midnight.

N. B. Since the Wind is very seldom considerable in foggy Weather, the Sound will be very seldom hinder'd by the Wind, when there is the greatest occasion for it ; that is, when the Air is too thick to permit the Light to be seen ; which is a great Convenience in that Case : tho' it must be own'd, that foggy Weather does it self damp Sounds very considerably.

N. B. If what is said by some well acquainted with Navigation be true, *viz.* that Fogs are much rarer in the main Ocean than near the Shores, our Method by the Ball of Light, nay, and by the Sound also, will

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will be there less interrupted than at and near the Coasts ; to the great Advantage of the most difficult Part of our intire Discovery.

N. B. If the Publick be willing to save part of the Charges of this intire Method, and be contented with the Light, without any very great Sound ; a moderate Mortar, and no great Quantity of Gun-Powder will suffice. But if it be thought fit to have the Sound as well as the Light, in their utmost Perfection, the largest Cannon-Royal, and its intire Charge of Powder, will be but necessary. Or it may be so contriv'd, that there be every where both a moderate Mortar for clear, and the largest Cannon-Royal for foggy Weather.

N. B. If there be any danger of mistaking one Explosion for another in any Case, the Light may be diversify'd ; and Balls of Fire whiter, redder, and bluer made use of,
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in a Row, according to one constant Order. Or, as my Lord *Pembroke* very well propos'd, the first Explosion may be single, the second in order double, at a certain Interval of Time; the third double at twice that Interval; the fourth double at thrice that Interval; and so on. By either of which Provisions this Ambiguity, if it any where should be suspected, may be intirely prevented. Tho' indeed at that great Distance of about 600 Miles, which we propose the Explosions at Sea to be from one another, any such Mistake is *there* next to impossible.

N.B. In case some parts of the Ocean prove so very rough and stormy that no Ships care to have their Stations in them, the way to recover the Longitude, which may be by this means interrupted, is rightly proposed by Sir *Isaac Newton* himself, in his Paper deliver'd in to the Committee of the House of Commons,

mons, *viz.* to fail obliquely from the last Buoy and Stationary Ship into the Parallel of the next, and so along the same ; till upon approaching to to them the Longitude be anew recover'd, and the Voyage be continued as before. Nor is this Interruption of any consequence ; because it cannot happen but in Places where there is no Danger of this Nature ; and where Seamen are under no great Concern for the knowledge of the Longitude.

OBSER-

OBSERVATIONS.

(1.) **I**F in all proper Roads of Ships such a Mortar, or Great Gun be plac'd and discharg'd, exactly every Midnight, whether on Shoars, or Islands, or in the Stationary Ships, at the Distances of about 600 Geographical Miles or 10 Degrees, All other Ships that sail within any tolerable Distance may commonly every Week or Ten Days thereby correct their Reckoning, and know their Longitude, as well as Latitude, even when the Heavens are not clear enough to make Celestial Observations for either.

(2.) The Ordinary Watches, Movements, or Log-Lines in Ships, when thus Corrected and Adjusted, once
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in a Week or Ten Days, will well enough shew the Longitude during every one of those short Distances between the Stationary Ships ; and so will render the Knowledge thereof still more universal.

(3.) The exacter therefore any Movements that may be used at Sea can be regulated, and adjusted to an even Motion, the more beneficial will they be in this Method. So that tho' any such Movements should not succeed so far, as themselves to discover the Longitude alone, of which there is indeed small Hopes ; yet if they be at all improv'd they will give Assistance in this or any like Method for its Discovery ; and will therefore justly deserve from the Publick both Approbation and Encouragement.

(4.) If one such Row of Stationary Ships be any where found too de-

defective, a double Row may there be laid, Pair by Pair, in the same [or equidistant] Meridians; with proper Distinctions in the Sounds, or the Light, to prevent mistaking one Row for the other. Nor will there, in this Case, be room for almost any Uncertainty, since even in Cloudy Weather, as much as the Wind carries away the Sound of any one, so much will it usually bring the Sound of another.

(5.) If it be any where necessary, Masts may be Erected upon Hollow Empty Vessels, with White Spheres at their Tops; and these Vessels may be fix'd in proper Places, at equal Distances between the Stationary Ships, for the more sure guiding the other Ships in Places of Danger. And since from the Top of any Mast that is 88 Feet High, the Top of another as high may be discovered at the Distance of 20 Miles,

there will hardly be occasion for more of these Vessels any where than one every 120 Miles: Nor will these Masts and Vessels be any Annual Charges at all.

(6.) Besides the Mortars or great Guns, and their solemn Explosions; In proper Places, at several Havens, where there is any Danger at the Entrance of Ships, as well as at other convenient Promontories jetting out into the Sea, a Rocket may be thrown up from the Top of a Neighbouring Steeple, or Hill, or the like most elevated Place, every Midnight, or Watch, or Hour, for the Seamens better Direction and Security.

(7.) Signals of all Sorts may be given by this Method, by mutual Agreement. As suppose in Storms we would know which way, and how strong the Wind is at the nearest

est Explosion, &c. Other Ships may thus give Signals of Distress to the Stationary ones, or to one another. The News of great Events may be also this way carried very soon over the Sea; especially, if any Ships were plac'd within Sight and Hearing of each others Signals, as a Fleet may sail in Times of Peace, &c. In short, no one knows how far this Method of Communication by these Kinds of Signals may be improv'd; and how great a Convenience may hence arise to the several Parts of the Globe; especially in the Way of Trade and Commerce; and even for the Propagation of Knowledge both Divine and Human throughout the World.

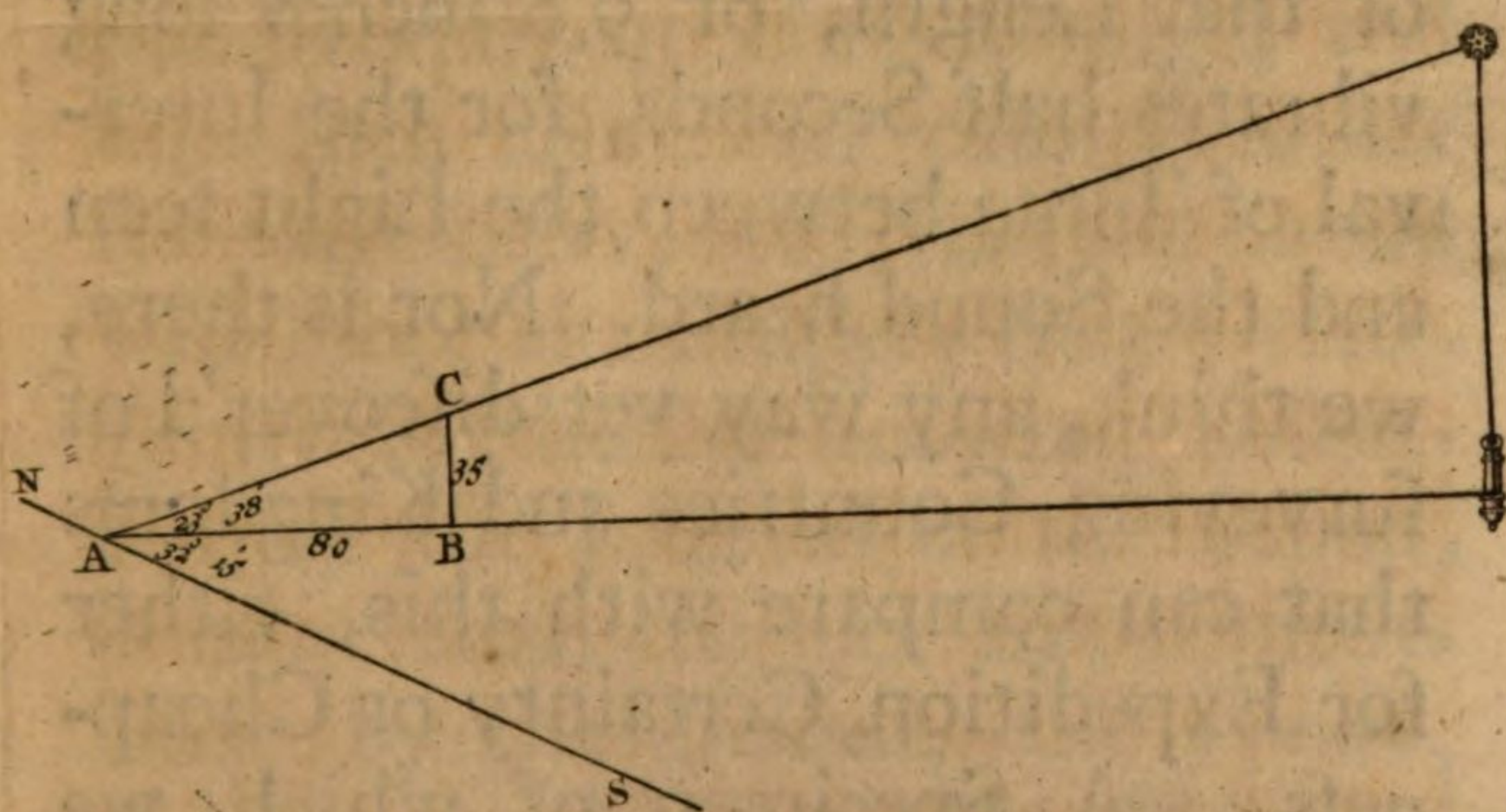
(8.) If in any clear and calm Night a sufficient Number of such Explosions were made at proper Distances in any Country, and convey'd in order from one to another; so

so that the Second Mortar or Gun were fired when the Light of the First was seen, or otherwise ; with the Observation of the exact apparent Times when they were made, when the Light was seen, what Angle, or how long that Light was above the Horizon, and what Azimuth it had ; both the Longitude and Latitude, as well as the Distance and Position of all these Places, might by this means be readily determin'd at Land ; especially if the Experiments were repeated several times, and were compar'd one with another. And by the same Observations every where, the Longitude and Latitude, Distance and Position, of all other Neighbouring Places from those, and so from another, might be readily determin'd also :

N. B. This Method of Survey is no hard Thing in Practice, even to those that know little of the Mathematicks :

for the Longitude. 87

matics : For any Right Angle, set by a Plummet or Level, with Two Pins or Points, for the Eye and for the Object, does by the Proportion of its Sides give the Angle above the Horizon ; by the Angle its Horizontal Side makes with the Meridian, it gives the Azimuth ; and by the Interval of Time between the Light and Sound, it gives the Distance of every Place from that of Explosion, according to the Figure following.



Where A B represents the Horizontal Side of the Norma or Square, and B C the Perpendicular Side ; whose

whose Proportion once given, as suppose 80 to 35, the Discovery of the Angle of Elevation C A B is most easy, as here $23^{\circ}. 38'$. Where also N S. represents the Meridian Line lying from North to South ; and the Angle S A B, suppose of 32 Degrees, 15 Minutes, represents the Azimuth, Eastward. We need not add that a Plummet of 39.2 Inches vibrates whole Seconds, as in long Pendulums, and of a quarter of that Length, or 9.8 Inches long vibrates half Seconds, for the Interval of Time between the Light seen and the Sound heard. Nor is there, we think, any way yet discover'd of surveying Countries and Kingdoms that can compare with this, either for Expedition, Certainty or Cheapness. A Specimen of which we hope soon to give the World in an Actual Survey of *Great-Britain* and *Ireland*, and their Coasts hereby ; if the Publick please to give us

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Encouragement and Assistance therein.

N. B. The Observation of the Altitude is at Land less exact than at Sea, because of the Inequality of Hills and Valleys, and the consequent Uncertainty how high any Mortar or Gun is above the level Surface of the Sea. However, it is plain that we don't want that Method in this Land Survey ; because we can place our Mortars or Guns so high, and take such clear and calm Weather for our Observations, that the Sound will more than supply that Defect. Which Method of knowing Distances, by the Interval of the Sound, is now, from the nice Experiments made by the *Italians*, the *French*, and by our Famous Mr. *Flamsteed* and the still more authentick ones of the Accurate Mr. *Derham*, become the most exact of all others for this Purpose. In order

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to which Design, I do here propose a Table for the Ease of all that make use of the same Method. See Mr. *Derham's* full Account of this Matter, *Transact. Philosoph.* N^o. 313.

A Table of the Velocity of Sounds in still Weather at 1142 Feet to one Second of Time.

Statute Miles,	Interval of the Sound.	Statute Miles.	Interval of the Sound.
1	4 $\frac{5}{8}$	19	87 $\frac{7}{8}$
2	9 $\frac{1}{4}$	20	92 $\frac{1}{2}$
3	13 $\frac{7}{8}$	21	97 $\frac{1}{8}$
4	18 $\frac{1}{2}$	22	101 $\frac{3}{4}$
5	23 $\frac{1}{8}$	23	106 $\frac{3}{8}$
6	27 $\frac{3}{4}$	24	111
7	32 $\frac{3}{8}$	25	115 $\frac{5}{8}$
8	37	26	120 $\frac{1}{4}$
9	41 $\frac{5}{8}$	27	124 $\frac{7}{8}$
10	46 $\frac{1}{4}$	28	129 $\frac{1}{2}$
11	50 $\frac{7}{8}$	29	134 $\frac{1}{8}$
12	55 $\frac{1}{2}$	30	138 $\frac{3}{4}$
13	60 $\frac{1}{8}$	31	143 $\frac{3}{8}$
14	64 $\frac{3}{4}$	32	148
15	69 $\frac{3}{8}$	33	152 $\frac{5}{8}$
16	74	34	157 $\frac{1}{4}$
17	78 $\frac{5}{8}$	35	161 $\frac{7}{8}$
18	83 $\frac{1}{4}$	36	166 $\frac{1}{2}$

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Statute Miles.	Interval of the Sound.	Statute Miles.	Interval of the Sound.
37	171 $\frac{1}{8}$	44	203 $\frac{1}{2}$
38	175 $\frac{3}{4}$	45	208 $\frac{1}{8}$
39	180 $\frac{3}{8}$	46	212 $\frac{3}{4}$
40	185	47	217 $\frac{3}{8}$
41	189 $\frac{5}{8}$	48	222
42	194 $\frac{1}{4}$	49	226 $\frac{5}{8}$
43	198 $\frac{7}{8}$	50	231 $\frac{1}{4}$

N. B. Double or triple the Seconds belongs to double or triple the Number of Miles. So that this Table will serve for any Distance and Time whatsoever.

N. B. Mr. *Derham*, in his Account of Sounds, did not only state this their Velocity with great Exactness, which is the principal thing in such a Survey; but did propose this very Use of it also, as to small Distances, so nearly to the present Observation, that he is to be allow'd to have gone a great way towards this Branch or Use of our Discovery.

N. B. Yet may it be proper, before any new Survey is made by this Method, to have this Velocity of Sounds try'd at larger Distances than that of twelve or thirteen Miles, which was the farthest that Mr. *Derham* had Opportunity for. I mean at 30, 40, or 50 Miles distance, where the Sound can be heard so far ; and this in some plain Country, and where the Distance can be exactly measur'd, in a strait Line, at the same Time. Which Tryal, if once done with sufficient Accuracy, will settle this Point for ever. The Rectilinear Canal call'd *New Bedford River* in the Isle of *Ely*, and the famous and strait Roman Road call'd *Watling-Street*, especially as it passes very nearly in a direct Line through the plain Country of *Staffordshire*, seem very fit places for this Experiment ; and accordingly in the Survey we are now going upon

upon, we have pitch'd upon them for the same Purpose.

(9) The way of casting a Shell to any Height is very easy: for the same Force or Charge of Gun-Powder that will cast any Shell twice as far for it utmost Random, at the Elevation of 45 Degrees, will certainly cast the same Shell perpendicularly upward as high as is requir'd; as we have already observ'd. And since the Time of any such entire perpendicular Projection, or Ascent and Descent together, may be known from a former Table; We have another sure Way of Adjusting the same Projection to that Height; *viz.* by observing what Quantity of Powder will cast the Shell high enough to stay a certain Interval in the Air, before it falls to the Ground; only the Resistance and Retardation by the Air is to be distinctly allow'd for.

(10.) This Method of firing Powder, or other combustible Matter, at, or very near the utmost Height, may be well enough put in practice, even tho' some considerable Error should be committed in the adjusting the Fusee to give Fire at such a Time. Since the Mistake of even a Fifth Part in Time, in that Case, would produce but an Error of the 25th Part of the whole Altitude: and the Mistake of a Tenth Part in Time, would occasion an Alteration of no more than the Hundredth Part thereof. This is evident, because this Time belongs to the highest Part of the Projectils Motion, which is the slowest: And because the Lines describ'd by all Ascending and Descending Bodies are still in a Duplicate Proportion of the Times of such their Ascent and Descent.

(11.)

(11.) If one or more Rows of such Stationary Ships were laid in the same or Equidistant Meridians, Southward or otherways, Ships might with greater Safety than formerly go to discover those Parts of the Globe which are hitherto undiscover'd. Nor can we at present guess what Advantages may thereby accrue to the Parts of the World already discovered.

(12.) If Foggy Weather be not sufficiently provided for by what has been already mention'd, the Stationary Ships may be laid closer, at least near the Shore; that so the occasional Defect of one, or sometimes two Explosions, *i.e* of one intire Stationary Ship's Assistance, may not produce any considerable Error in sailing. Tho' it must be remembred, that this Foggy Weather hinders the Observation of the
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Latitude; and that Clouds also which hinder us not, do yet hinder the same: which Latitude yet is always esteem'd to be discover'd notwithstanding: and that all the Harm which need ensue thereby is only the delay of a few Days in a Voyage, till the Air clears up: without the incurring of any Danger in the mean time.

(13.) Every one of these Stationary Ships may be Places of Observation as to the Variation of the Needle, to the Currents, to the Soil, the Fowls, the Fishes, and other *Phænomena* of the several Places where they are fixed; and an excellent Means of keeping up a mutual Correspondence between the several Parts of the Globe, for all useful Purposes whatsoever.

(14.) These Stationary Ships will be an excellent Nursery for skilful Sailors;

Sailors ; and will use them to the greatest Dexterity in handling and working of Ships to the best Advantage.

(15.) As this Method ought to be put in Practice at Sea by the Consent of all Trading Nations ; so ought every one of the Stationary Ships employ'd therein to have a legal Protection from them all : And it ought to be a great Crime with every one of them, if any other Ships either injure them, or endeavour to imitate their Explosions, for the Amusement and Deception of any.

(16.) Since the Charges of the Powder for each Mortar will be very small ; since the Shells may be generally the same, and their Contents come to no great Price neither ; since the Persons employ'd in the Stationary Ships may be in part taken out of such Places where they

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are maintain'd at the Publick Charge already ; and so will require only some Additional Rewards, or Future Privileges for such their Service ; since the Number of such Stationary Ships need be but small, scarcely more than Fifteen, or Twenty at the most ; and since the Land Explo- sions, which will be much the most numerous, will be withal much the cheapest ; It will appear upon the Whole, that the Annual or Constant Expences of this Method will be comparatively very small and incon- siderable ; especially if they are, as they ought to be, equally distribu- ted among the several Trading Na- tions of the World.

The Advantages of this Method.

(1.) **T**HIS Method requires no Depth of Astronomy, no Nicety in Instruments, and but seldom any Celestial Observations at all, either as to the Latitude, or the Hour at the Ship; and so is to even the common Sailors the *most Practicable*.

(2.) It does generally determine the very Place of the Ship, both as to *Longitude* and *Latitude* at once, and so is the *most Compendious*.

(3.) It does generally determine the very Place to a few Miles, at the farthest ; and so is the *most Accurate*.

(4.) It sometimes affords Help even in Cloudy and Foggy Weather, when no Celestial Observations can be made, and the *Latitude* it self cannot be otherwise found, and so is the *most General*.

(5.) It will frequently afford a double Observation Two successive Nights, from the same Stationary

Ship to the same sailing Ship, and so is the *most Secure*.

(6.) It will frequently afford a double way of Observation at the same time, by the Eye and by the Ear, which will confirm or correct one another ; and so is the *most Certain*.

(7.) The more inaccurate Branch, by the Sound, is not only more universal than the other ; but is also much more exact than any Method formerly discover'd : So that in that Case this Way is certainly the *very Best*.

(8.) It is the most undoubted and exact near the Shores, where there is the greatest Want and Danger : And if it should at all be deficient, it is in the wide Ocean, or there only where there is no such Danger, and hardly any Occasion for knowing the Longitude, as has been shew'd already. So that on all Accounts it is plainly the *most Useful and Advantageous*.

A P.

APPENDIX.

N. B. **I**T being of great Advantage, both in our present Survey of this Kingdom, and upon many other Occasions, to know the true Altitude and Distance from the North of the Pole-Star at all times: I shall here add Tables to find the same to every half Hour of its distance from the Meridian, for the Latitude of 53° . which is nearly that of the middle of *England* and *Ireland*; and they will well enough serve for both Kingdoms, and for all other Countries that lie in the same Parallels with them.

Hours.		Diff. Altitude above the Pole.			Distance from the North.		
		0	1		0	1	
XII	XII	2	13	$\frac{1}{3}$	0	0	
$\frac{1}{2}$	$\frac{1}{2}$	2	12	$\frac{1}{6}$	0	30	$\frac{1}{3}$
XI	I	2	8	$\frac{3}{5}$	I	0	$\frac{1}{2}$
$\frac{1}{2}$	$\frac{1}{2}$	2	2	$\frac{2}{3}$	I	29	$\frac{1}{5}$
X	II	I	54	$\frac{1}{2}$	I	56	
$\frac{1}{2}$	$\frac{1}{2}$	I	44	$\frac{2}{5}$	2	20	$\frac{3}{4}$
IX	III	I	32	$\frac{2}{3}$	2	42	$\frac{1}{2}$
$\frac{1}{2}$	$\frac{1}{2}$	I	18	$\frac{2}{5}$	3	0	
VIII	IV	I	3	$\frac{5}{8}$	3	16	$\frac{5}{8}$
$\frac{1}{2}$	$\frac{1}{2}$	0	48		3	28	$\frac{2}{3}$
VII	V	0	31	$\frac{1}{2}$	3	36	$\frac{1}{3}$
$\frac{1}{2}$	$\frac{1}{2}$	0	14		3	45	$\frac{1}{4}$

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Hours.		Diff. Altitude below the Pole.		Dist. from the North.	
		0	1	0	1
VI	VI	0	3 $\frac{1}{3}$	3	41 $\frac{1}{3}$
$\frac{1}{2}$	$\frac{1}{2}$	0	20 $\frac{2}{10}$	3	38
V	VII	0	38	3	31
$\frac{1}{2}$	$\frac{1}{2}$	0	53 $\frac{5}{8}$	3	20 $\frac{3}{5}$
IV	VIII	1	9 $\frac{1}{5}$	3	6 $\frac{5}{6}$
$\frac{1}{2}$	$\frac{1}{2}$	1	23 $\frac{2}{5}$	2	50 $\frac{1}{3}$
III	IX	1	36	2	31
$\frac{1}{2}$	$\frac{1}{2}$	1	47	2	9 $\frac{3}{5}$
II	X	1	56 $\frac{1}{3}$	1	46
	$\frac{1}{2}$	2	3 $\frac{2}{3}$	1	21
I	XI	2	9	0	54 $\frac{2}{3}$
$\frac{1}{2}$	$\frac{1}{2}$	2	12 $\frac{1}{4}$	0	27 $\frac{1}{2}$
XII	XII	2	13 $\frac{1}{3}$	0	0

N. B. If we always deduct the right Ascension of the Sun from the right Ascension of the Pole Star, which is now 0^s. 9°. 15'. the Remainder will correspond to the Time of the Pole Stars coming to the Meridian above the Pole : and 12 Hours before or after will be the Time of its coming to the same Meridian under the Pole. Thus, because 11°. in *Aries* corresponds to 9°. 15'. of right Ascension ; when the Sun is there, which is *March* 20th, the Pole Star comes to the upper Meridian at Noon.

And

And because 191° . of the Ecliptick, where the Sun is *Sept.* 22d, has 189° . $15'$. right Ascension, the Pole Star comes to the same Meridian at Midnight ; and in both Cases its Hours from that Meridian agree with the ordinary Reckoning of Hours with us. At other times it comes sooner than the Sun about $4'$. every Day, or an Hour in about 15 Days. Thus *April* 22d this Year, the Day of the great Solar Eclipse, the Sun's right Ascension is 40° . $15'$. which deducted from 9° . $15'$. or 189° . $15'$. the Remainder is 149° . $0'$. This shews that the Pole Star comes to the upper part of the Meridian at 9^h . $56'$. before Noon ; which is nearly $4'$. for a Day, or an Hour for 15 Days, along the Ecliptick. And so in all other Cases whatsoever.

N. B. It is farther humbly propos'd to the Learned, Whether it may not be proper for all Nations, upon this Occasion, to agree upon one
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first Meridian, or beginning of *Longitude*, for the common Benefit of *Geography*? And whether it may not be proper, in that Case, to fix it to the *Pike of Teneriff*, as the most noted Place already; and as the Place whence the Highest and most generally useful *Explosion* may, in this Method, be made every *Midnight* continually, for the *Discovery* of the *Longitude* it self?

A D V E R T I S E M E N T S.

Lately publish'd, Proposals for a New Survey of *England* and *Wales*, according to this Method for Discovering the *Longitude*; and for a new Sett of correct Maps of the several Counties, according to such a Survey, by Subscription, at Two Guines the whole Sett, bound in Pastboard, are to be had *Gratis* at Mr. *Whiston's* in *Cross-Street*, *Hatton-Garden*; at Mrs. *Ditton's* in *Christ's Hospital*; at Mr. *Senex's* at the *Globe* near *Salisbury-Court*, *Fleet-Street*; at Mr. *Hauksbee's* in *Crane-Court* near *Fetter-Lane*, *Fleet-Street*; and at the Booksellers of *London* and *Westminster*, and of the several County Towns.

As also, Mr. *Whiston's* *Copernicus*, or Universal Astronomical Instrument for finding the New and Full Moons, and the Eclipses of the Sun and Moon; with the Exhibitions of them both, by an easy and natural Method, never before publish'd: Together with the Places and Aspects, both *Heliocentrical* and *Geocentrical*, the Directions, Stations, and Retrogradations of the Planets, both primary and secondary, for any Time past, present, or to come; according to the True or *Copernican* System: With a small Book, giving plain Directions for the Use of it. The Prices are Four Guineas with the Globe and Frame; Three with only the Frame; and One and an half without either.

Whiston, William,

A new method for discovering the Longitude both at Sea and Land

London 1715

Astr.p. 181 b

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